REMARKS

Claims 1-28 are pending in this application. Claims 1, 15, and 26 have been amended. New claims 29-37 have been added. No new matter has been added with the amendments and new claims. Support for the amendments and new claims can be found throughout the specification as originally filed, for example, in at least ¶¶ 6, 24, 26, 29, and Figs. 3-6.

Applicants thank Examiner Patel for the telephonic interview on August 13, 2008. During the interview, Applicants' representative discussed the claimed invention and distinguished the claimed invention from the teachings of the cited references. The comments and remarks presented during the interview are incorporated in the substantive response below.

By way of review, the pending application is directed to an optical system and method for **real time** processing of a **medical image of bodily tissue** to **dynamically identify abnormal pathological changes** in the input medical image. The motivation of the invention is the recognition that early detection of cancer is extremely important for the successful treatment of cancer. In one embodiment, the systems and methods of the present invention use the **original medical images** such as, for example, mammograms and Pap smears, in which the abnormal changes, e.g., microcalcifications, are buried in surrounding tissue. The invention provides for apparatus and methods that use spatial frequency filtering to enhance the desired components while filtering out the undesired components present in the medical images, so that a radiologist or a pathologist can more easily diagnose and prescribe appropriate treatment (See for example, ¶3 of published application).

In one embodiment, a light source emits a light beam directed at the input medical image. A lens Fourier transforms the light passing through the image at the Fourier plane. In that Fourier plane, an **adjustable spatial filter** is used to **selectively remove** certain undesirable frequency components and allows the transmission of the remaining desirable components. A desirable frequency component is dynamically selected such that it is associated with the abnormal pathological changes in the medical image. A second lens inverse Fourier transforms the resulting filtered spectrum to form the processed image.

Claim Rejections – 35 U.S.C. § 103

2. Claims 1-2, 5-10, 13, 15-16, and 19-24 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Rao et al. (U.S. 5854710) (hereafter Rao) in view of Alfano et al. (U.S. 5710429) (hereafter Alfano).

Rao is directed to systems and methods for optical Fourier processing of input images **based on photoinduced anisotropy of photochromic materials** (Abstract). In Rao, the Fourier transform of a polarized beam from the optical image illuminates a photochromic material film along with a polarized actinic beam. The actinic beam causes a **rotation of the angle of polarization** of the image beam by different angles at different locations on the film corresponding to different spatial frequencies (Col. 10, Lines. 25-64, Fig. 1). The resulting beam is then inverse Fourier transformed and passed through **an analyzer, which performs low-, band-, and high-pass filtering**, and notch filtering (Id.; Col. 12, Lines. 38-44).

Alfano is directed to imaging an **object in or behind a highly scattering medium**. Alfano's technique separates different temporal components of the light scattered from turbid media. A **light source illuminates the highly scattering medium**. The light that emerges from the medium itself consists of ballistic, snake-like, and diffusive components. The emerged/transmitted light is Fourier transformed. The ballistic component and most of the snake-like component of the light are transformed onto the center optical axis, while the diffusive component is transformed more or less uniformly around the central optical axis on the Fourier plane. A spatial filter, an aperture, centered at the Fourier plane filters out most of the diffusive component and allows the ballistic and snake components to pass through. The resulting light is collected by another lens and detected by a photo detector, which **forms an output image** (Col. 3, Lines. 47-Col. 4, Line. 1, Fig. 1).

Applicants submit that Rao does not teach or suggest every element of the independent claim 1. For example, contrary to what was stated in the Office Action, Rao does not disclose "an adjustable spatial filter in the Fourier plane that filters the transformed light by selectively removing a first frequency component and transmitting a second frequency component, wherein the second frequency component is dynamically selected to associate with the abnormal pathological changes in the input medical image." The film in Rao's Fourier plane does not filter Fourier components of the image beam, rather it rotates the polarization angle for some Fourier components.

In its assertion otherwise, the Office Action states:

> Rao discloses [a spatial filter] (Element 12 spatial filter Col 4 Lines 1-20 which shows that the light irradiated on 12 (film) will allow the film to transmit a plurality of polarization components (freq components of one type since they are polarized) and blocking the other which is due to the polarization acting as a spatial filter. This is further explained in Col 10 Lines 13 and 36-42). This property of polarization will function as spatial filter. Further (Figs 4A-4D and Col 13 Lines 27-67 shows that polarization acts as a spatial filter (Office Action, page 3).

Applicants, however, submit that, Rao at least does not disclose a spatial filter as recited in the pending claims. Specifically, the above cited excerpts from Rao state:

> In another aspect, the invention features a method of spatial filtering of optical image data. First, the method includes irradiating a film including a photochromic material with an input beam. The input beam carries an input image. The method also includes polarizing the input beam to generate a polarized input beam. Next, the method includes focusing the polarized input beam onto the photochromic film by Fourier transformation and illuminating the photochromic material film with a polarized actinic beam such that the film transmits a variably polarized image beam including a plurality of polarization components. Then, the method includes retrieving the variably polarized image beam from the photochromic material film by an inverse Fourier transform and generating an output image beam by arranging a polarizing analyzer in the path of the variably polarized image beam to selectively block a specific set of polarization components. Finally, the method includes detecting the output image with a radiation detector. The actinic beam is set at a wavelength and intensity to induce in the photochromic material anisotropy that varies as a function of the intensity of total illumination on the photochromic material (Col. 4, Lines 1-20) (emphasis added).
>
> Optical processing, i.e., spatial filtering, in the optical processing system is accomplished by providing an optical input image having a single linear polarization, and then processing that input image to generate an output image that contains a range of linearly polarized light of varying orientations corresponding to the different spatial frequency components of the optical input image. This permits the use of an analyzer, e.g., a

rotatable polarizer, after an inverse Fourier transformation, which blocks specific polarization components of the transformed image, which in turn spatially filters the image to produce the output image (Col. 10, Lines 13-22) (emphasis added)

If optical input beam 14 was not already polarized, this image is polarized by polarizer 18, and passes through lens 20, which forms a Fourier transform of the optical input image 16' on the photochromic film 12. Lens 22 then forms the inverse Fourier transform to generate the processed image 16" at the output image plane 26, e.g., a CCD camera. The only alignment of these elements required is that the lenses focus the transformed images on the appropriate plane (Col. 10, Lines 34-42).

Actinic beam 28, generated by radiation source 28', illuminates the photochromic film 12 where it is or will be illuminated by the optical input image 16'. ... For the actinic beam, the light source must induce a dichroism in the photochromic material that predominates over any induced birefringence. This dichroism produces a rotation of the plane of polarization of the input image beam passing through the dichroic parts of the film. This actinic beam-induced angular rotation of the optical input image beam and its dependence on probe beam intensity profile at the Fourier plane, as explained in further detail below, are the basic principles employed by the optical Fourier processing system (Col. 10, Lines 43-64) (emphases added).

FIG. 4A shows the result of high frequency spatial filtering, so-called "edge enhancement," when the input image is the inner opening of a razor blade. On illuminating the film 12 with actinic beam 28 having an intensity of about 10 mW/cm.sup.2, only the edges of the opening in the razor blade appear in the processed output image 16" at the output image plane 26, e.g., CCD, giving the desired edge enhancement.

This self-adaptive edge enhancement can be explained as follows. The Fourier transform of an object image formed on the photochromic material film has an intensity distribution with high intensities for low frequency components (such as the main area of the opening in the razor blade) and low intensities for high frequency components (such as the edges of the opening in the razor blade). The graph in FIG. 3 shows that at an optimum actinic beam intensity, the effect of increasing the input beam intensity is to decrease its degree of polarization rotation due to photoinduced dichroism. Therefore, high frequency components at the bR plane experience a higher degree of polarization rotation than the zero and low frequency components. Hence, if the input image has a single linear polarization, after its passage through the bR film under actinic light illumination, it has a range of polarizations of different orientations that depends on the intensity (and, thus, the frequency) of the components.

Fourier processing is accomplished through the analyzer, which blocks specific polarization components, which in turn blocks the corresponding spatial frequencies. When the analyzer is arranged to polarize at right angles to the input beam polarization, zero and low frequency components which experience almost no polarization rotation due to their high intensities are blocked by the analyzer. However, the high frequency components corresponding to the edges of the razor blade opening experience a polarization rotation and at least in part pass through the analyzer to appear at the CCD camera to give edge enhancement.

Rotation of the analyzer can work as a variable spatial filter for Fourier processing. Thus,

> the edge enhancement becomes a more broadly applicable notch filter that selectively blocks a specific set of frequencies (Col. 13, Lines 27-67) (emphases added).

Contrary to what the Office Action articulates, neither the above excerpts, nor any other section in Rao, disclose that element 12 (the photochromic film) is a spatial filter and that the irradiation on the film "will allow the film to transmit a plurality of polarization components and block the other as a spatial filter." Instead, they teach that the photochromic film 12 merely rotates the plane of polarization of different spatial frequency components of the optical input image at different angles and transmits, not block, all those components. Further, after an inverse Fourier transformation of all those transmitted components, the analyzer 24, a rotatable polarizer which is not located at the Fourier plane as required by the recited spatial filter, blocks specific polarization components of the transformed image. The spatial filtering in Rao is based on the above mechanism and does not disclose "an adjustable spatial filter in the Fourier plane that filters the transformed light by selectively removing a first frequency component and transmitting a second frequency component." In other words, Rao's film 12, which is located in the Fourier plane, does not remove a first frequency component, but it transmits all frequency components, after rotating the plane of polarization of some of them.

Moreover, as the cited excerpts show, Rao's system relies on the actinic beam to enable the photochromic film to perform the above function. In the absence of a second light source emitting the actinic beam, Rao's system will not be functional. The claimed invention, on the other hand, does not rely on such a second light source, and only utilizes "a light source emitting light directed at the input medical image of bodily tissue."

The Office Action also asserts that:

> Both the references [i.e., Rao and Alfano,] teach the limitations of claim 1 combined or separately … Alfano [among other things] discloses … Light source (Fig. 1 elements 13 col 3 line 48 (Office Action, page 2).

Applicants, however, submit that, Alfano does not disclose all limitations of the claimed invention. Specifically, it does not disclose "a light source emitting light directed at the input medical image of bodily tissue; a first optical Fourier element that Fourier transforms light from the input medical image …, an adjustable spatial filter in the Fourier plane that filters the transformed by selectively removing a first frequency component and transmitting a second frequency component, wherein the second frequency component is dynamically selected to associate with the abnormal pathological changes in the input medical image," as recited in amended claim 1. Instead, as Fig. 1 shows and the above cited excerpt states, in Alfano "a collimated beam of light 13 is incident on a highly scattering medium 15" (Col. 3, Lines 48-49) (emphasis added). Alfano explicitly states that "[i]t is an object of [Alfano's] invention to provide a novel imaging technique useful in the detection of hidden objects in scattering media" (Col. 1, Lines 36-38), and that the "novel idea of Fourier spatial gating can be used to image objects hidden behind or inside a scattering media" (Col. 2, Lines 55-57). Thus, Alfano's light source emits light that is directed at a scattering medium instead of an input image, and he processes light scattered from a scattered medium instead of an input image.

The scattering medium is an essential element of Alfano's disclosure. Because in Alfano the "light emerging form the highly scattering medium consists of a ballistic component, snake-like component and a diffuse component … [Alfano's system] is used to form a time gated image of the emerging light, the time gated image consisting primarily of the ballistic component and the snake-like component" (Abstract, emphasis added). Thus Alfano's system is used as a time gating device to remove some of the components scattered from a scattering medium, and he has no recognition of a system with an input medical image of bodily tissue.

Alfano's system, similar to Rao, does not disclose an adjustable spatial filter which selectively transmits a frequency dynamically selected to associate with the abnormal pathological changes in the input medical image. Instead, Alfano is concerned with lights scattered at different times and thus selects his filters to select those lights accordingly.

Applicants further contend that Alfano does not supply that which is missing from Rao. As described above, Alfano is related to the imaging of an object hidden in a scattering medium, while both Rao and the present application are related to systems for image processing of a previously captured image to enhance the detection of abnormalities that are medically significant. In Alfano, the input light emerges from a scattering medium which includes an object, and Alfano intends to form an image of that object as an output (Abstract, Col. 1, Lines. 7-9). On the contrary, in Rao a medical image is used as an input and Rao intends to process that image. Similarly, the present invention is related to processing input images, more specifically, processing of medical images of bodily tissue. Thus Alfano's invention is directed to a scope that is different from that of Rao or the present invention, and it would not have been obvious to one of ordinary skill in the art to combine Rao with Alfano in a manner that results in the presently claimed invention.

In addition, Applicants submit that, the combination of Rao and Alfano does not render the present claimed invention unpatentable. If Rao is combined with Alfano, Rao's system must be installed at the tail end of Alfano's system, i.e., to receive as an input that which forms the output of Alfano's system. Alfano's system forms an image of an object (e.g., the image at location 25 in Fig. 1), and Rao's system analyzes and performs different types of filtering of that image. This combination does not supply the features that are missing from Rao, specifically the spatial filter that is missing from the Fourier plane of Rao.

In its rebuttal of the above argument, the Office Action states that:

> Applicant further argues … that "the combination of Rao and Alfano is not proper, the examiner disagrees. First of all Rao shows that the input beam carries an input image (Col 3 Lines 36-37) and as seen from figs 4A-4D shows input images of the body. Alfano also discloses in fig 1 element 15 (object) is being irradiated. The image which the applicant is arguing on remarks page 8 line 8 is the detected output image which is an enhanced image (optically filtered image). Thus Alfano discloses "spatial filtering at fourier plane" at (Col 5 Lines 31-34). Both Rao and alfano disclose "spatial filtering" in the optical processing therefore Rao and Alfano are combinable (Office Action, pages 3-4).

Contrary to what the Office Action states, Rao's Fig. 4B in an input image of a razor blade and Figs. 4A, 4C, 4D, are the processed images, i.e., output images, for that input image (Col. 6, Lines 43-52). Alfano's output image, on the other hand, is the image of an object hidden in a scattering medium, as explained above. Thus, the cited excerpt confirms that Alfano is related to the imaging of an object hidden in a scattering medium, while Rao is related to systems for image processing of a previously captured image.

Further, the pending claims of the present application are not rendered obvious by the cited references, since they respond to a long standing demand in the medical community which has not been addressed by the cited references. Rao utilizes an arrangement which requires two beams, a polarizer, an analyzer, and a photochromic material (bR) film (Fig. 1). On the other hand, the present claimed invention, by utilizing a mechanism different from that of Rao, replaces the above elements simply with one beam and an adjustable spatial filter and use low cost optical spatial filtering systems. Alfano uses spatial filtering for an entirely different application and object – separating of diffused and ballistic photons after propagating through a scattering medium. As a result, the present application provides a "cost effective optical system for image processing ... [which] includes a low cost, durable, portable battery operated system for rapid screening of mammograms and Pap smears" (see for example, ¶6). Such a solution has not been addressed in the ten years since Rao was patented. Instead, during this period, other solutions have been pursued which use digital image processing schemes that rely on computers and which are more expensive and less feasible for small budget medical centers (see ¶4). In contrast, the present invention provides a low cost solution, for example, for radiologists or other medical experts, to process mammograms or pap-smears for example, in real-time and to detect breast cancer or other forms of cancer in an early stage (see for example ¶39).

Independent claims 15 and 26 recite limitations similar to the above elements of independent claim 1, and are similarly rejected based on Rao and Alfano. All other claims depend from one of these independent claims. Thus, Applicants contend that, at least for the above reasons, all rejected claims are patentable.

3. Dependent claims 11, 12 and 25 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Rao in view of Alfano and in further view of Buchan (US 3700902). The rejection relies on Buchan to supply the controller recited in claim 11, the processor, image storage, and display device recited in claim 12, and the controller and electronic representation recited in claim 25. Claims 11 and 12 depend from independent claim 1, and claim 25 depends from independent claim 15. Buchan that teaches the use of an electrooptic filter does not supply to Rao and Alfano the above mentioned limitations of independent claims 1 and 15 that Rao and Alfano are missing. Thus, regardless of whether or not Buchan supplies the listed extra limitations recited in

claims 11, 12, and 25, and at least for the reasons stated earlier, these claims are patentable over Rao, Alfano and Buchan.

4. Dependent claims 3, 17, 4, and 18 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Rao in view of Alfano and in further view of Trezza (US 20020067535). The rejection relies on Trezza to supply the mammogram recited in claims 3 and 17, and the Pap smear recited in claims 4 and 18. Claims 3 and 4 depend from independent claim 1, and claims 17 and 18 depend from independent claim 15. Trezza does not supply to Rao and Alfano the above mentioned limitations of independent claims 1 and 15 that Rao and Alfano are missing. Thus, regardless of whether or not Trezza supplies the mammogram and Pap smear as recited in claims 3, 17, 4, and 18, and at least for the reasons stated earlier, these claims are patentable over Rao, Alfano and Trezza.

5. Dependent claim 14 has been rejected under 35 U.S.C. 103(a) as being unpatentable over Rao in view of Alfano and in further view of Beraudo (US 4625325). The rejection relies on Beraudo to supply an input image that has a size of less than 10 cm^2, as recited in claim 14. Claim 14 depends from independent claim 1. Beraudo does not supply to Rao and Alfano the above mentioned limitations of independent claim 1. Thus, regardless of whether or not Beraudo supplies the listed extra limitations recited in claim 14, and at least for the reasons stated earlier, claim 14 is patentable over Rao, Alfano and Beraudo.

6. Claims 26-28 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Rao in view of Alfano and in further view of Burke et al (US 6421454). The rejection relies on Burke to supply the mammographic image recited in these claims. Claims 27 and 28 depend from independent claim 26. Burke does not supply to Rao and Alfano the above mentioned limitations of independent claims 26 that Rao and Alfano are missing. Thus, regardless of whether or not Burke supplies the mammographic image to claims 26-28, and at least for the reasons stated earlier, these claims are patentable over Rao, Alfano and Burke.

In view of the above remarks, Applicants submit that the pending application is in condition for allowance, and request such action.

Please charge the fee for the nine added new claims and any other fee that is due to our Deposit Account No. 08-0219, or credit any overpayments, under Order No. 1823430.00123US2 from which the undersigned is authorized to draw.

Respectfully submitted,

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Monica Grewal

Monica Grewal
Registration No.: 40,056
Attorney for Applicant(s)

Wilmer Cutler Pickering Hale and Dorr LLP
60 State Street
Boston, Massachusetts 02109
(617) 526-6000 (telephone)
(617) 526-5000 (facsimile)